

Effect of a Single Short-Term Reduction in Photoperiod on Photorefractoriness in Turkey Hens

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ABSTRACT In a prior study, we reported that a high proportion of hens in a winter-laying flock became relatively photorefractory (rPR) early in the reproductive cycle and that successive short-term reductions in photoperiod in such hens each initially depressed egg production but then caused a rebound in rate of lay to briefly exceed that of hens that did not exhibit rPR. The present study was conducted to assess rPR in a summer-laying flock and to determine whether a single short-term reduction in day length early in the reproductive cycle might enhance egg production and delay the onset of absolute photorefractoriness (aPR). Control hens received a photoperiod of 16L:8D throughout the experiment. Experimental hens were photostimulated with 16L:8D, received a reduced (but still stimulatory) photoperiod of 11.5L:12.5D for 2 wk beginning 8 wk after photostimulation, and then were returned to 16L:8D for the remainder of the 23-wk test period. Results showed that a single 2-wk reduction in day length shortly after the hens reached

peak egg production did not significantly reduce overall flock egg production, but it also did not improve late-season egg production or retard the onset or incidence of aPR. The incidence of rPR was substantially less in this study than we had observed with a winter-laying flock (32.9 vs. 67.1%), but similar proportions of treated hens exhibited the most severe rPR response (a brief but complete cessation of egg production) in both studies (21.1 vs. 24.0%), and all treated hens that subsequently became aPR had shown this severe rPR response to the test photoperiod. We concluded that a core proportion of hens (approximately one-fifth) exhibited a strong rPR response when presented with a reduced photoperiod early in the reproductive cycle, regardless of season of the year, and that such hens were more likely to subsequently exhibit poor egg production or become aPR than flockmates that did not exhibit rPR. Therefore, some indication of the incidence of rPR early in the lay period may have a predictive value for the overall egg production of the flock.

(Key words: photoperiod, photorefractoriness, turkey)

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INTRODUCTION

The turkey is, by nature, a photoperiodic species and a seasonal breeding bird. Photosensitivity must be induced by a short photoperiod before normal breeding can begin. In a commercial setting, maximum photosensitivity is induced with a period of light restriction for at least 8 wk (a photoperiodic winter) prior to photostimulation for sexual maturity. Once photosensitive, a turkey hen will initiate and continue lay when provided with any day length that exceeds the critical day length (CDL) for photoperiodic drive. This varies by season and for optimum egg production is approximately 11 to 11.5 h in winter and at least 14 h in summer (Siopest, 1994). In

practice, hens are photostimulated with a long day length of at least 14 h light (14L:10D), which substantially exceeds the CDL at any time of year and results in a rapid onset and high peak of egg production. During the ensuing reproductive season, neuroendocrine changes cause the hen to gradually become unresponsive to the day length that initially stimulated reproduction. The hen may first become relatively photorefractory (rPR), when she will cease laying only if photoperiod is reduced, and then she may become absolutely photorefractory (aPR) and cease laying despite an unchanging, long day length.

Our prior studies have shown that turkey hens exhibit rPR and aPR (Siopest, 2001; Proudman and Siopest, 2002). Most recently, our results have shown that rPR may be present in a majority of hens by 8 wk after photostimulation and that rPR is likely a lesser form of, and precedes,

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Abbreviation Key: aPR = absolute photorefractoriness; CDL = critical day length; FR = full responder; NR = nonresponder; PAR = partial responder; PR = photorefractory; rPR = relative photorefractoriness

aPR (Siopes and Proudman, 2003). In these studies, the presence of rPR was demonstrated by a 2-wk reduction in photoperiod from a day length that provided a strong photoperiodic drive (16L:8D) to a day length that marginally exceeded the CDL (11.5L:12.5D) for the winter season and had a reduced, but still stimulatory, photoperiodic drive. The reduced photoperiodic drive lowered or terminated egg production in hens that were rPR, but, because rPR is reversible, a return to the initial photoperiod immediately restored egg production. In fact, egg production rebounded in hens exposed to periods of shorter day length, significantly exceeding the rate of lay of control hens after some treatment periods (Siopes and Proudman, 2003).

In photoperiodic species, photorefractoriness (PR) is dissipated (and photosensitivity restored) by providing sufficient weeks of a photoperiod that is below the CDL. But can inhibitory influences on reproduction also be partially dissipated and perhaps PR delayed by a short-term reduction in photoperiod to a day length that is below the requirement for PR but is marginally above the CDL for photostimulation? Siopes (1998) has shown that any photoperiod greater than 12 h will initiate the inhibitory inputs leading to PR in turkey hens. Other reports (reviewed by Nicholls et al., 1988) suggest that the depression of egg production and the onset of PR may be enhanced by longer photoperiods. Intuitively, it seems possible that during the normal laying period a short-term reduction in day length to a photoperiod less than the CDL for PR and exceeding the CDL for photoperiodic drive may partially dissipate the weak inhibitory inputs characteristic of rPR and delay the onset of aPR. If true, this should have little or no negative effect on ongoing egg production and result in more persistent lay. Indeed, our previous study (Siopes and Proudman, 2003) reported a lower incidence of aPR in hens that received 3 successive 2-wk periods of 11.5-h photoperiods if the hens received the first photoperiod treatment before development of a strong rPR response. However, this study also showed that successive applications of shortened photoperiods severely reduced overall egg production and thus would not have application to a commercial flock.

The present study was conducted to explore the possibility that a single light treatment (reduced day length) early in the reproductive cycle may dissipate early inhibitory inputs (rPR) and thereby enhance egg production by delaying onset of aPR. A further objective was to assess the incidence of rPR in a spring breeder flock. Our prior study (Siopes and Proudman, 2003), using hens photostimulated in September and laying through the winter, revealed the presence of rPR in a majority of hens (67.3%) by 8 wk after photostimulation. Because a summer laying flock should have an earlier onset of aPR than a winter laying flock (Siopes, 2002), a difference in the incidence

and degree of rPR at the same point in the reproductive cycle may provide new information on the relationship between rPR and aPR.

MATERIALS AND METHODS

Birds

Female parent line BUTA² strain 37 roaster turkeys were raised from 1 d of age following the guidelines of the primary breeder. This same line of turkeys was used in the winter study by Siopes and Proudman (2003). Birds were raised on a 14L:10D photoperiod until 18 wk of age and then on a 6L:18D photoperiod until 30 wk of age. Hens were moved at 29 wk of age to laying pens in 2 rooms with independent light control of sodium vapor lamps set to deliver 50 lx at bird height. Birds were photostimulated at 30 wk of age (April 5) with a photoperiod of 16L:8D (lights on 0500 h). Egg production and nesting activity were monitored by trap-nesting, with the nests checked and hens expelled 5 times per day. Any hens that became broody or that did not lay consistently in the trap nests were removed from the experiment. At 8 wk after photostimulation (June 8), one room of hens ($n = 76$) was changed to a photoperiod of 11.5L:12.5D (on at 0500 h) for 2 wk and then returned to 16L:8D for the remainder of the experiment. The 11.5L:12.5D photoperiod provided the near-maximum photoperiodic drive allowable without activation of PR processes. It should be noted however that 11.5 h of light per day in the spring-summer season is well below the amount of light needed for maximum egg production. The other room of hens ($n = 73$) remained on 16L:8D throughout the experiment. Hens (either treated or control) that spontaneously ceased laying on a photoperiod of 16L:8D and had regressed ovaries on necropsy were deemed aPR ($n = 9$).

Hens receiving the photoperiod treatment were classified as nonresponders (NR), partial responders (PAR), and full responders (FR), as described previously (Siopes and Proudman, 2003). Briefly, NR hens did not differ significantly in egg production from control hens during and immediately following the light treatment; FR hens ceased egg production for at least 7 d in response to the light treatment, and PAR hens exhibited a significant decline in egg production but did not pause in lay for more than 6 consecutive days. Therefore, NR hens were fully photosensitive, whereas PAR and FR hens differed in the degree of rPR exhibited at the time of the photoperiod treatment.

Statistical Analysis

One-way ANOVA was used to evaluate treatment effects using the GLM procedures of the SAS Institute (1990). The least squares mean option was used to estimate significant differences among treatment means. Statements of statistical significance are based on $P < 0.05$.

²British United Turkeys of America, Lewisburg, WV.

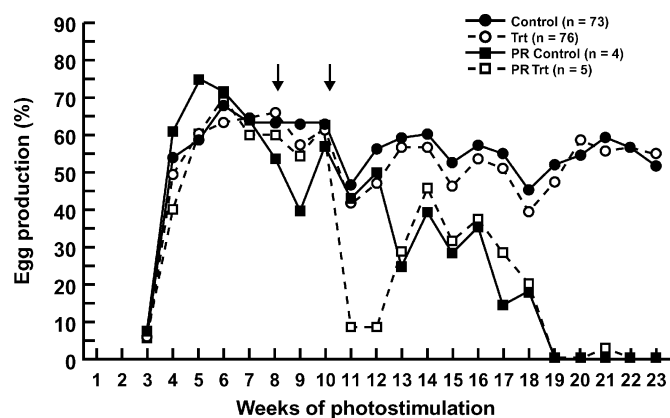


FIGURE 1. Percentage hen-day egg production for hens receiving a reduction in photoperiod (trt) from 16L:8D to 11.5L:12.5D for 2 wk starting at 8 wk of photostimulation and then returned to 16L:8D (arrows). Controls remained on 16L:8D throughout. The egg production of hens from each group that became absolutely photorefractory (PR) during the treatment period is also shown.

RESULTS

The mean percentage hen-day egg production of control and photoperiod-treated hens is shown in Figure 1. Mean hen-day egg production of control hens was 57.0%, whereas that of hens receiving a 2-wk shortened photoperiod was 54.2% ($P > 0.05$). Figure 1 also shows the egg production of hens that became aPR during the experiment. The overall incidence of aPR during this 23-wk reproductive cycle was low (9 of 149 hens; 6%). Egg production curves of control and treated hens that became aPR indicate that the photoperiod treatment did not alter the expression of aPR despite a substantial drop in production immediately following the photoperiod treatment in the treated group. Minor declines in egg production in all hens at 11, 15, and 18 wk of photostimulation (Figure 1) coincided with periods of unusually hot weather.

The incidence of rPR among the hens that received a shortened photoperiod between 8 and 10 wk of photostimulation was 32.9% (Figure 2). Nine of these hens (11.8%) were PAR, whereas 16 hens (21%) were FR. Egg production did not differ between control and NR hens but was significantly lower in PAR and FR hens immediately following the photoperiod reduction and at several points later in the reproductive season (Figure 2). Interestingly, all photoperiod-treated hens that subsequently became aPR were from the FR group.

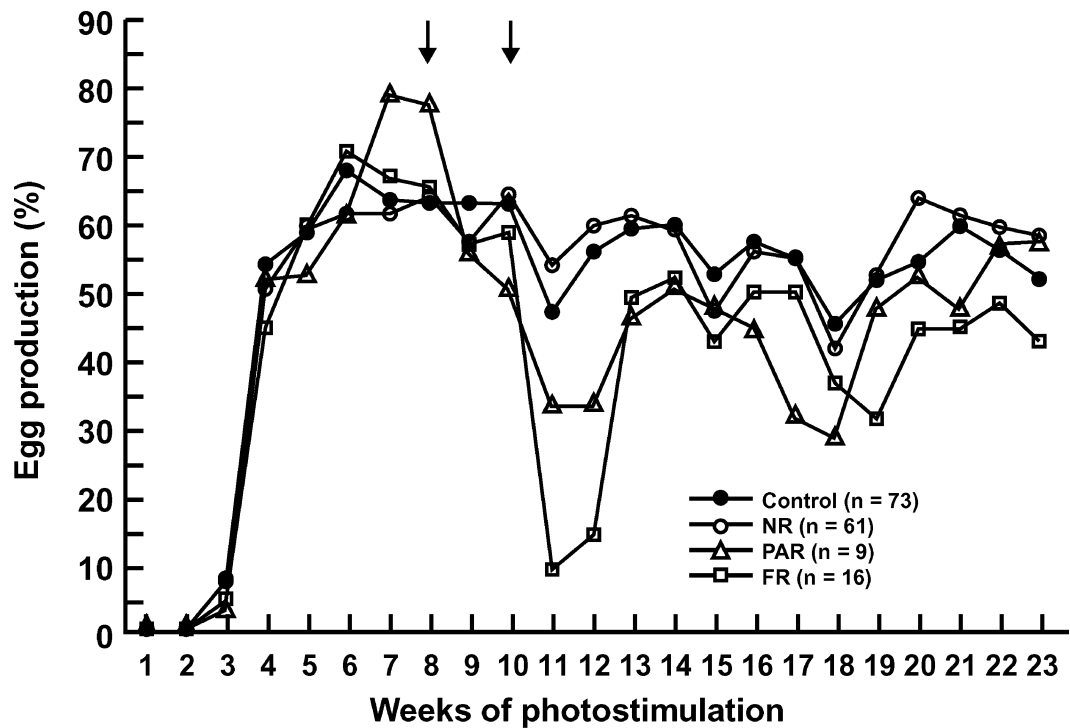
DISCUSSION

A single 2-wk reduction in day length shortly after the hens reached peak egg production did not significantly reduce overall flock egg production, but it also did not improve late-season egg production or retard the onset or incidence of aPR (Figure 1). Thus, our results do not support the hypothesis that a short-term reduction in photoperiod early in the lay period to a level below the

CDL for aPR, but still providing photoperiodic drive, improves subsequent egg production. Possibly providing the 11.5L:12.5D photoperiod for a longer period or perhaps reducing the length of this treatment photoperiod would have different results. However, we have recently observed that use of 8L:16D in similar circumstances did not alter the results (Siopes, unpublished data).

The egg production response to the reduced (11.5L:12.5D) photoperiod was heterogeneous, as in our previous report (Siopes and Proudman, 2003), in that there were again nonresponders (NR), partial responders (PAR), and full responders (FR). Clearly there was considerable variation in photoresponsiveness among the hens early in the lay period, which presumably relates to egg production potential (Figure 2). This study confirms our previous finding that rPR occurs early in the reproductive cycle of turkey hens and shows that this response also occurs in a summer-laying flock. The incidence of FR hens in the present study (21.1%) was similar to that observed in our winter-laying flock (24.0%; Siopes and Proudman, 2003), and all hens that subsequently became aPR were in this response group. However, the proportion of rPR hens observed in the summer flock (32.9%) was markedly lower than that observed at the same number of weeks (8) after photostimulation in a winter-laying flock (67.1%, Siopes and Proudman, 2003) due to a much lower proportion of PAR hens. This finding was somewhat surprising as we expected at least as great an incidence of rPR in summer-laying hens as in winter-laying hens. This is not to say that the development of neuroendocrine factors inhibiting reproduction was slower in our summer- than winter-laying flocks. It may be that low rPR in the summer was simply a consequence of normal high variability in rPR among flocks, like that for aPR (Siopes, 2001). In addition, differences between studies in lighting (fluorescent vs. sodium vapor) and housing (cages vs. floor pens) might have contributed to the difference in number of PAR hens. Nevertheless, we interpret this result to suggest that a core percentage of hens within a flock exhibit a strong and highly variable rPR response early in the reproductive cycle regardless of season and that this variability in rPR seems to be associated with the PAR-type hens.

Because the incidence and degree of rPR increases as the lay period progresses, and because rPR precedes aPR (Siopes and Proudman, 2003; Follett and Nicholls, 1984; Nicholls et al., 1988; Bentley et al., 1997), these rPR hens are likely to later exhibit aPR at a higher rate (and have lower associated egg production) than their flockmates. Therefore, some indication of the incidence of rPR early in the lay period may have a predictive value for the overall egg production of the flock. The full significance of a high or low incidence of rPR hens early in the reproductive cycle cannot be determined from the present study, because the proportion of such hens that subsequently became aPR after 23 wk of photostimulation was low. An extended study would likely provide an improved incidence of aPR hens because the expected mean onset of aPR for summer laying hens is about 18 wk



Treatment	Weeks of photostimulation																				
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Control	-	-	-	-	b	b	-	-	a	a	-	-	-	-	a	a	a	a	a	-	-
NR	-	-	-	-	b	b	-	-	a	a	-	-	-	-	a	ab	a	a	a	-	-
PAR	-	-	-	-	a	a	-	-	b	b	-	-	-	-	b	b	ab	ab	ab	-	-
FR	-	-	-	-	ab	ab	-	-	c	c	-	-	-	-	ab	ab	b	b	b	-	-

FIGURE 2. Percentage hen-day egg production for subgroups of the treated hens. All treated hens received a reduction in photoperiod from 16L:8D to 11.5L:12.5D for 2 wk starting at 8 wk of photostimulation and then were returned to 16L:8D (arrows). Subgroups were based on the degree of decline in egg production in response to reduced photoperiods at the 8-wk treatment period and consisted of nonresponders (NR), partial responders (PAR), and full responders (FR). Controls were maintained on 16L:8D throughout. Treatment means within any week of photostimulation without common letters are different ($P < 0.05$).

of photostimulation (Siopes, 2002). An extended study would, therefore, allow a better evaluation of the significance of rPR early in lay. However, the present data indicate that at least some (FR group) of the rPR hens had significantly lower egg production later in the season than did NR hens. Therefore, we conclude that hens that respond to a short-term reduction in photoperiod early in the reproductive cycle by reducing or ceasing egg production are likely to be poorer producers later in the season than those that do not, and such photoperiod treatment does not rejuvenate egg production or alter the onset of aPR at least to 23 wk of photostimulation.

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